ECE/BIOM 581B1 Cells as Circuits

Fall 2016

9:30-10:50 am Tues/Thurs in Engineering B4

Instructor: Kevin Lear
Email: KLLear@engr.colostate.edu
Important note: You must include "581B1" as part of the subject line for all emails regarding this class, or else my email filters will not highlight them.
Phone: 970-491-0718
Office: Scott 346
Office Hours: 3-4 pm Tuesdays, 11:00-11:30 and 2:30-3:00 most Thursdays

This course is a module in the GAUSSI series, developed in part to support the NSF-sponsored GAUSSI program. Courses in this series include:
Cells as Circuits - 78125 - ECE 581B1 - 001 (Fall, Lear)
Signal and Noise in Biosensors - 27177 - ECE 581B2 - 001 (Spring, Lear)
Sensor Circuit Fundamentals - 27179 - ECE 581B3 - 001 (Spring, Chen)
Affinity Sensors - 27181 - ECE 581B4 - 001 (Spring, Chen)
Electrochemical Sensors - 78105 - ECE 581B5 - 001 (Fall, Chen)
Biophotonic Sensors Using Refractive Index - 27183 - ECE 581B6 - 001 (Spring, Lear)

COURSE DESCRIPTION: Treatment of biological cells as circuits and their electrical time-dependent function and frequency dependent impedance. Topics include the Hodgkin–Huxley circuit model, diffusion equation and definitions of biosensor performance metrics.

COURSE OBJECTIVES: Upon successful completion of this class, students will be able to:

- Draw an equivalent circuit model for biological cells and calculate the frequency dependent impedance of cells from the equivalent circuit
- Describe the temporal evolution of action potentials and corresponding states of ion distributions and ion channel permeability in terms of circuit variables
- Write solutions to the diffusion equation satisfying varying flux and concentration boundary conditions, choose appropriate boundary conditions and parameters for realistic physical configurations, calculate fluxes from solutions, and interpret time and length scale parameters of problems
- Define and quantitatively relate linearity, dynamic range, chemical sensitivity, diagnostic sensitivity, specificity, selectivity, limit of detection, standard deviation, variance, false positive rate and false negative rate

PREREQUISITES: BIOM101 or LIFE102; CHEM111; PH142; MATH255 or MATH261; MATH340 or MATH345, may be taken concurrently

REQUIRED MATERIALS: There is no required textbook for this class. Readings and notes will be provided as needed.

Canvas: canvas.colostate.edu will have the syllabus, links, homework, course grades and other postings. It is your responsibility to check the course website each week for new postings.

COURSE TOPICS: The planned topics for this course are:

Week 1	Current-voltage characteristics of resistors, capacitors, batteries, and current sources. Structure and circuit equivalence of cellular components including membrane, cytosol, ion channels and pumps. Anatomy and function of a neuron (overview).
Week 2	Diffusion, diffusion equation, and its solutions for various boundary conditions
Week 3	Electrical conductivity, combined diffusion and E-field drift of ions, electrochemical potential, Nernst equation, membrane potential; Hodgkin–Huxley model, action potential, voltage-gating, refractory periods, combined temporal dynamics
Week 4	Frequency dependent impedance of cells and tissue; Coulter counter, introduction to electrical impedance tomography
Week 5	Sensor performance metrics and the relationships between them; International Union of Pure and Applied Chemists (IUPAC) definitions; Final exam or Project

GRADING:

Quizzes / participation in discussions 10%
Homework assignments 45%
Final exam or project 45%

Homework will be due at the start of class one week after it is assigned, typically each Thursday, but check the website for updates. Links to the homework can be found on Canvas. I request that you record the time spent on each question on your paper.

The final exam for this course will occur in class on Thursday, October 27th at 9:30 AM.

Final grades will be determined by the following scale:

≥ 90% A	80-83.99% B	70-73.99% C
87-89.99% A-	77-79.99% B-	60-69.99% D
84-86.99% B+	74-76.99% C+	≤ 59.99% F

ACADEMIC INTERGRITY: Students are expected to adhere to the Academic Integrity Policy of Colorado State University, outlined in the CSU General Catalog. Students are also expected to follow the Student Conduct Code which can be found at www.conflictresolution.colostate.edu. Academic dishonesty is not accepted in this course, and any form of cheating (including plagiarism) will be reported. Penalties may include a lowered course grade, loss of course credit, and expulsion from the university.